

6. Debugging Tools

6.1 Turbulence Model Diagnostics (DEBUG=1)

An OVERFLOW turbulent quantity debug option is included by specifying the **&GLOBAL** NAMELIST input parameter **DEBUG=1**. Turbulent parameters of interest are written to a “fake Q file” **q.turb**. Familiarity with respective turbulence model quantities is required if meaningful insight is to be expected. Different turbulent quantities are written to the **q.turb** file depending on the turbulence model selected in the OVERFLOW input file.

The file **q.turb** is based on the flow solution input in **q.restart**. The NAMELIST input expected when using **DEBUG=1** is identical to the input required to continue the current OVERFLOW solution using the **RESTRRT=.TRUE.** option. Note that the **DEBUG=1** option does not take a complete step through the solution, so **NSTEPS** is ignored in the NAMELIST input.

A detailed listing of parameters written to **q.turb** is given in the Tables 6.1-6.6. The row beginning with $(J,K,LS, _)$ denotes turbulent quantities stored at the surface, in this case L is the normal direction. The row beginning with $(J,K,L, _)$ denotes turbulent quantities stored throughout the field defined by the **&VISINP** section of the NAMELIST input.

For the Baldwin-Barth and Spalart-Allmaras R_T models, a turbulence index is returned at the surface in $Q5$. This variable ramps from 0 (laminar flow) to 1 (turbulent flow), with a value of -2 indicating invalid data ($|\omega|=0$, for example).

When using PLOT3D, it is critical to remember that only grid functions and explicit Q functions are meaningful. The **q.turb** file should be read using:

```
read/unformatted/mgrid/blank/nocheck/x=grid.in/q=q.turb
```

The **/nocheck** option is important, in that without it, PLOT3D will interpret the Q file as containing flow variables, and may modify values to avoid negative density or pressure. Use **/ieee** instead of **/unformatted** for double-precision grid and Q files.

Table 6.1 Debug output for Baldwin-Lomax and Degani-Schiff turbulent quantities (NQT=0 and ITTYP=1).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>
$(J,K,LS, _)$	F_{max}	y^+	$ \omega $	μ_w	-
$(J,K,L, _)$	$F(y)$	y	$ \omega $	μ_t	<i>F_{max} location</i>
					1 inner
					2 outer
					3 outer wake
					-1 F_{max}

Table 6.2 Debug output for Baldwin-Lomax and wake model turbulent quantities (NQT=0 and ITTYP=11).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>
$(J,K,LS, _)$	F_{wake}	$\frac{u_{diff}}{ \omega _{max}}$	$ \omega $	μ_t	$ \omega _{max} location$
$(J,K,L, _)$	$ \omega _{max}$	y	$ \omega $	μ_t	$ \omega _{max} location$
					4 wake
					-1 $ \omega _{max}$

Table 6.3 Debug output for Baldwin-Barth R_T 1-equation model turbulent quantities (NQT=100).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>

$(J,K,LS, _)$	$c_\mu D_1 D_2$	y^+	$ \omega $	μ_t	Turbulence index
$(J,K,L, _)$	$c_\mu D_1 D_2$	$f_2(y^+)$	$ \omega $	μ_t	Transition factor

Table 6.4 Debug output for Spalart-Allmaras R_T 1-equation model turbulent quantities (NQT=101,102).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>
$(J,K,LS, _)$	f_{vI}	y^+	$ \omega $	μ_t	Turbulence index
$(J,K,L, _)$	f_{vI}	y	$ \omega $	μ_t	Trip/Transition factor

Table 6.5 Debug output for k- ω 2-equation model turbulent quantities (NQT=202 or 204).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>
$(J,K,LS, _)$	ω	y^+	S_{ij}^2	μ_t	Turbulence index
$(J,K,L, _)$	ω	y	S_{ij}^2	μ_t	k

Table 6.6 Debug output for SST 2-equation model turbulent quantities (NQT=203 or 205).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>
$(J,K,LS, _)$	ω	y^+	F_I	μ_t	Turbulence index
$(J,K,L, _)$	ω	y	F_I	μ_t	k

6.2 Timestep Diagnostics (DEBUG=2)

A diagnostic “fake Q file” **q.time** can be generated by running OVERFLOW with the **&GLOBAL** input parameter **DEBUG=2**. Running the code with **DEBUG=2** requires the same input files as the **DEBUG=1** option described above. The five field quantities returned in **q.time** are (Δt , CFL_j , CFL_k , CFL_l , and CFL_{max}). These correspond to the NAMELIST **&TIMACU** variables **ITIME**, **DT**, **CFLMIN**, and **CFLMAX** specified in the input file.

6.3 Residual Diagnostics (DEBUG=3)

A diagnostic “fake Q file” **q.resid** can be generated by running OVERFLOW with the **&GLOBAL** input parameter **DEBUG=3**. Running the code with **DEBUG=3** requires the same input files as the **DEBUG=1** option described above. The five field quantities returned in **q.resid** are the residuals of the five conserved variables.

6.4 Solution Adaption Information (DEBUG=4)

A diagnostic “fake Q file” **q.errest** can be generated by running OVERFLOW with the **&GLOBAL** input parameter **DEBUG=4**. The first three field quantities returned in **q.errest** are the error estimation sensor function; the marker array indicating whether the local grid resolution should be coarsened (-1), refined (+1), or maintained (0); and \log_{10} of the sensor function. Other field quantities are currently not used.

6.5 Reynolds Stress Turbulence Model Diagnostics (DEBUG=5)

A diagnostic “fake Q file” **q.reystr** can be generated by running OVERFLOW with the **&GLOBAL** input parameter **DEBUG=5**. Six field quantities are returned: τ_{11} , τ_{21} , τ_{31} , τ_{22} , τ_{32} , τ_{33} . These include quadratic constitutive relation (QCR) terms, if appropriate.